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OCR A Level Computer Science

H446 – Paper 1

4

Stacks

Unit 7
Data structures

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Objectives

- Be familiar with the concept and uses of a stack
- Be able to describe the creation and maintenance of data within a stack
- Be able to describe and apply the following operations: push, pop, peek (or top), test for empty stack, test for full stack
- Be able to explain how a stack frame is used with subroutine calls to store return addresses, parameters and local variables

Abstraction

- Three abstract data types (ADTs) covered so far are a queue, list, and linked list
  - How are the concepts of data hiding and encapsulation used in the implementation of an abstract data type?

Stack definition

- Think of a stack of textbooks
  - The teacher adds to the top of the stack
  - The students removes from the top of the stack
  - Last In First Out = LIFO

Using a stack

- Many examples of stacks occur in everyday life – can you think of examples?
  - Can you think of any examples related to computing?
  - What operations are needed to implement a stack?

Modelling a stack

- The basic operations needed are:
  - Add an item to the top
  - Remove an item from the top
  - Check if the stack is full
  - Check if the stack is empty

Programming operations

- These methods could be written to implement the required functionality of a stack
  - push(item) – adds item to the top of the stack
  - pop() – removes and returns the item on the top of the stack
  - isFull() – checks if the stack is full
  - isEmpty() – checks if the stack is empty
- You might also want to write methods to:
  - peek() – return the top item without removing it
  - size() – return the number of items on the stack

Using a stack ADT

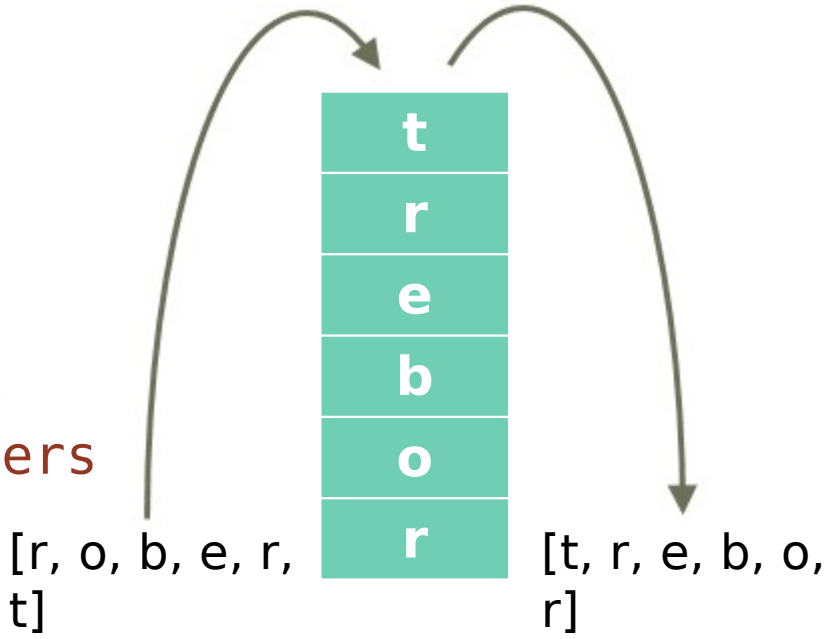
- In computing, a stack is an important data structure; one reason is that the order of insertion is the reverse of the order of removal
- Suppose you pop the letters r, o, b, e, r, t from a list letters, pushing each one onto a stack s
  - Now remove all these letters from the stack, adding each letter back into the list – what does the list look like now?

Algorithm for reversing a list

```
letters  ["r", "o", "b", "e", "r", "t"]

for each letter in letters
   remove letter from front of list
   push letter onto s
Next letter

For each letter in s
   pop letter from stack
   append letter to letters
Next letter
```



Implementing a stack as a list

- It's very easy to implement a stack as a list
- What list methods could you use to implement these functions?
  - Add an item to a stack
  - Remove an item from a stack
  - Check if the stack is empty
  - Find the number of items in the stack

Using a list

- Using built-in list operations, you could use the following list methods:
  - append(item) – add item to the top of the stack
  - pop() – remove and returns the item on the top of the stack
  - len(stack) – find the length (height) of the stack

Worksheet 4

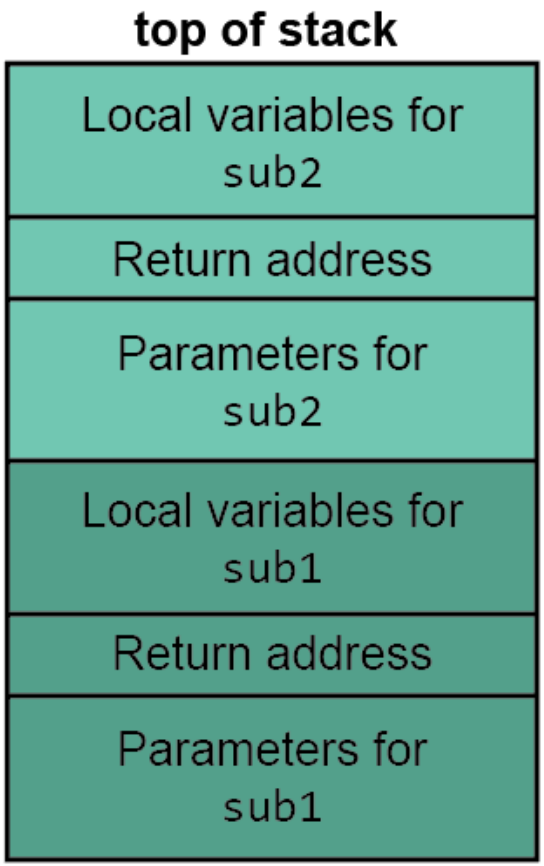
- Complete **Task 1, questions 1 and 2** of the worksheet

Overflow and underflow

- Overflow – attempting to push onto a stack that
  is full
- Underflow – attempting to pop from a stack that
  is empty
  - Note that if a stack is implemented using a dynamic list structure, there may be no “stack full” test. The computer may simply give a “stack overflow” error when it runs out of memory

Call stack

- The call stack is a system level data structure
- It provides the mechanism for passing parameters and return addresses to subroutines
- In high-level programming languages the use of the call stack is hidden from the programmer



Call stack

- What happens when this code is executed?

```
bigger = max (num1, num2)
```

- The programmer doesn't need to know how the arguments (`num1`, `num2`) are sent to the function `max`, or how the result is returned to the calling program
- The values of `num1` and `num2` and the return address (the line after the call statement), are saved on the stack
- These values are popped when the function completes

Subroutine calls

- Calls to subroutines are executed as follows:
  - The parameters are saved onto the stack
  - The address to which execution returns after the end of the subroutine is reached is saved onto the stack
  - Execution is transferred to the subroutine code

Subroutine execution

- Subroutines are executed as follows:
  - Stack space is allocated for local variables
  - The subroutine code executes
  - The return address is retrieved
  - The parameters are popped
  - Execution is transferred back to the return address

Plenary

- Describe a stack
- Describe the operations on a stack
- Give examples of the use of a stack
- Compare the behaviour of a stack with the behaviour of a queue

Plenary

- Stack - a last-in, first-out data structure
- Operations: PUSH and POP, test for full and empty stack
- Uses:
  - Holding return addresses, parameters and local variables when subroutines are called
  - Holding website addresses just visited
  - Holding operations just performed in word processor, spreadsheet etc.
- Compare with a queue – queue is FIFO, stack is LIFO

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